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REPORT OF THE ASSESSMENT METHODS WORKSHOP FOR SHARKS MARCH 14-15, 1989

By

David B. Holts and Dennis Bedford

ADMINISTRATIVE REPORT LJ-89-11

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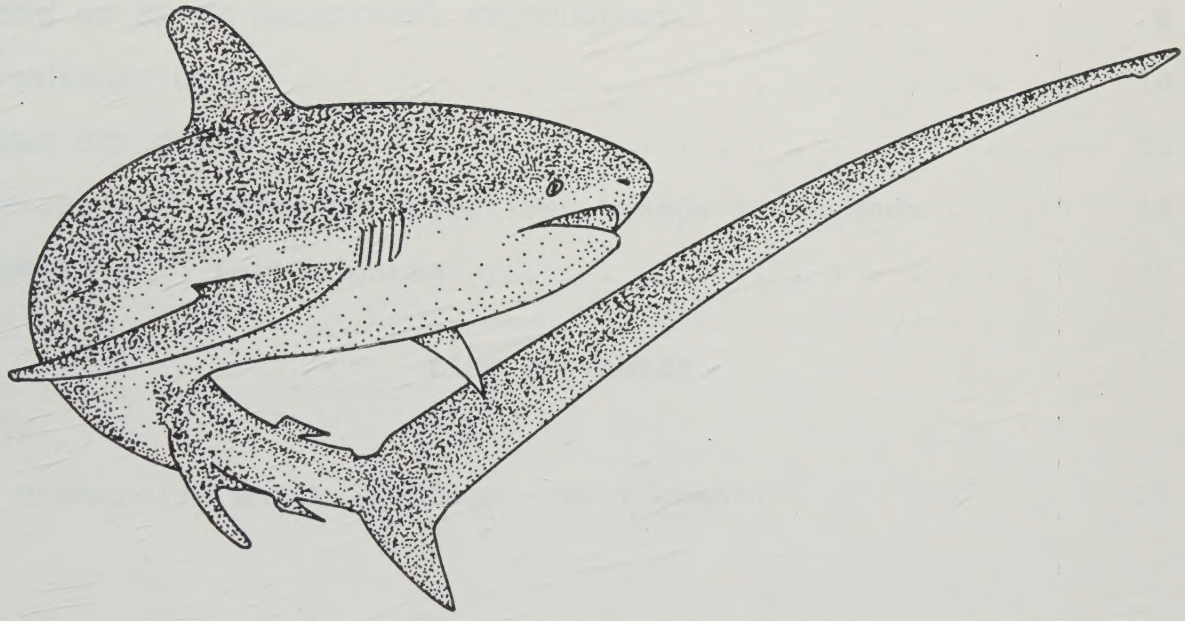
REPORT OF THE ASSESSMENT METHODS WORKSHOP FOR SHARKS

March 14-15, 1989



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CONTENTS

	Page
INTRODUCTION.	1
REVIEW OF WEST COAST SHARK FISHERIES.	2
STATUS OF AVAILABLE FISHERY DATA FOR SHARKS	4
STATUS OF AVAILABLE BIOLOGICAL DATA FOR SHARKS.	6
STATUS OF STOCK ASSESSMENT METHODOLOGY.	8
RECOMMENDATIONS	10
LITERATURE CITED.	15
APPENDIX A. Workshop objectives, venue and agenda	18
APPENDIX B. Participants.	20

LIST OF TABLES

Table	
1. Commercial shark landings - west coast.	17

REPORT OF THE ASSESSMENT METHODS WORKSHOP FOR SHARKS

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INTRODUCTION

The Assessment Methods Workshop for Sharks was convened to review the current analytical approaches and recent advances in stock assessment methods of west coast shark populations. Elasmobranch reproduction rates are very low due to low fecundity, slow growth rates and late age of maturity. This makes them extremely vulnerable to overharvesting (Holden 1973, 1974, 1977).

After the decline of the soupfin shark (*Galeorhinus zyopterus*) fisheries for vitamin A rich liver oil that occurred during World War II and the subsequent production of synthetic vitamin A, shark was viewed as a resource of little value until the late 1970's when popular interest created new market demands world-wide. Domestic landings and imports of numerous shark species have increased several fold during the last decade (Holts 1988). Landings on the west coast of the United States increased steadily through 1985 and (excluding dogfish) have since declined (Table 1). Because of this there is an increasing need for careful monitoring and assessment of exploited shark populations in order to prevent stock depletion in these fisheries.

The purpose of this workshop was to identify the best method of assessment for each commercially exploited west coast shark species, based on available fishery dependent information and known biological parameters. Our focus was on the status of available fishery and biological data and on analytical approaches that could best be employed to provide an objective assessment of specific stocks.

The Workshop was co-sponsored by the National Marine Fisheries Service (NMFS) Southwest Fisheries Center (SWFC) and the California Department of Fish and Game (CDFG), Long Beach. It was held at the SWFC, La Jolla, California on February 15 and 16, 1989. The working agenda and list of participants are in appendices I and II.

REVIEW OF CURRENT WEST COAST SHARK FISHERIES

Thresher Shark Fishery

The drift gill net (DGN) fishery for thresher sharks (*Alopias vulpinus*) began developing off the southern California coast in 1977 (Bedford 1983). Market demand grew rapidly and the fishery was further stimulated by the more valuable by-catch of swordfish (*Xiphias gladius*). Despite several attempts to limit it, the fishery grew and expanded for several years. Swordfish became the primary target species and the number of permitted vessels grew to 188 in 1981. Thresher shark landings peaked in 1982 at 2.4 million pounds and has declined in each of the following years (Bedford 1987). Legislation passed in 1986 limited the directed thresher shark fishery to 30 days during the month of May. Approximately 50 percent of the annual catch is taken during this period while the remainder of the catch is taken as a by-catch in the swordfish fishery during the fall and winter months. Only 500,000 pounds were landed in 1988.

Small amounts of thresher shark were landed in Oregon and Washington in 1983, 1984, and 1985. A permit-only DGN fishery landed 646,600 pounds in 1986 and 243,900 pounds in 1987. The total number vessels landing thresher shark in 1986 and 1987 was 37 and 33 respectively (Stick and Hreha 1988). In 1988 landings declined further with only six vessels landing 103,800 pounds (Stick and Hreha 1989).

Market sampling of length frequencies indicated the combined fishery was having a significant impact on the middle sized, immature and young adult animals (Bedford 1985). The Oregon and Washington fishery was taking a much greater proportion of larger, adult animals most of which were males. Pending California legislation (Assembly Bill No. 394), if passed, would eliminate the thresher shark target fishery in 1989. Oregon and Washington are similarly considering terminating their experimental DGN fishery due to 1) high catch of mature animals that could negatively impact recruitment and 2) to a non-marketable by-catch (Stick and Hreha 1989).

Shortfin Mako Shark Fishery (sometimes called Bonito shark)

Shortfin mako sharks (*Isurus oxyrinchus*) are taken primarily as an incidental but valuable by-catch in the California swordfish and thresher shark fisheries. Only a few individuals have been taken off Oregon and Washington. The catch is almost entirely composed of juveniles although some mature adults are taken. Catches rates quadrupled in 1980, peaked at 527,700 pounds in 1982 and, following the thresher shark fishery, declined to 215,000 pounds by 1985. A few long-line vessels began working the southern California Bight in 1986 and 1987 and landings increased. California opened an experimental, 10

vessel, long-line fishery for shortfin mako and blue sharks (*Prionace glauca*) in 1988. Continuation of this experimental fishery into 1989 requires that a market be developed to utilize the by-catch of blue sharks.

Blue Shark Fishery

The only fishery directing effort at blue sharks occurred in 1979 and 1980 when one long-line vessel fished for blue and mako sharks off southern California. This vessel landed 3,800 and 8,000 pounds blue shark respectively in 1979 and 1980 (West Coast Fisheries Development Foundation 1981).

The greatest source of fishing mortality for blue sharks occurred from their incidental capture during the developmental years of the DGN fishery off southern California. Preliminary annual mortality estimates were 15,000 to 20,000 sharks during that period. Changes in gear design and time-area closures reduced this incidental take although there are no current mortality estimates in this fishery. A small percentage of blue sharks are also taken in the set net fisheries for Pacific angel shark (*Squatina californica*) and for California halibut (*Paralichthys californicus*).

The current experimental long-line fishery off southern California targets shortfin mako sharks. This fishery is limited to ten permitees. To continue this experimental fishery into 1990, these permitees must develop a market for the blue sharks and eliminate discards.

Angel Shark Set Net Fishery

A local fishery for angel sharks began developing in the Santa Barbara Channel during 1978 (Richards 1986). After overcoming initial marketing problems, the fishery expanded at an explosive rate and in 1985 replaced the thresher shark as the principal food shark from southern California. These bottom dwelling sharks remain alive in the nets and small fish (less than 42 in) are returned to the sea in good condition. Landings exceeded 1.2 million pounds in both 1985 and 1986 (Bedford 1987). The catch declined to 940,000 pounds in 1987 and to about 500,000 pounds in 1988. This is a result of a combination of declining availability and alternative sources of low cost imported shark meat.

Soupfin Shark Fishery

More than 24,000,000 pounds of soupfin shark (*Galeorhinus zyopterus*) were landed from the waters off California in the eight years ending in 1944. This fishery decimated the soupfin population. A very small but consistent set net fishery for soupfin sharks has persisted over the past couple decades.

Landings in this fishery, including incidental catches from other boats have roughly averaged between 150,000 and 250,000 pounds.

STATUS OF AVAILABLE FISHERY DATA FOR SHARKS

Data collected by the CDFG are available for the drift and set gill net fisheries. This includes the common thresher, shortfin mako, blue, Pacific angel and soupfin sharks.

Landing Data

Most landings of pelagic sharks, prior to 1977, were recorded on the landing receipts as total pounds of "shark." Current market receipts show pounds caught of each species, date landed, area fished, and value. Data are entered as received with minimal editing. There is probable under reporting (of unknown levels) and capture areas are unreliable.

Log Books

Log books have been required for the drift gill net fishery since 1980 (thresher, mako and blue sharks). This data includes vessel, date, catch area, catch in pounds and numbers, effort, and gear. There is no single comprehensive data file. Forms are coded by seasonal aids and provided to individual researchers. Hand tallied summaries of effort and catch as well as some data subsets are available.

Log books from the set net fisheries for angel and soupfin sharks have the same status as for the drift gill net fisheries.

NMFS has begun punching DGN logs for swordfish and thresher sharks. Set net logs are only included if they occur on a log sheet with DGN sets. Several types of errors occur here but most can be resolved with computer edit programs.

Log books for California's experimental longline fishery are required for the 1988 and 1989 seasons. The data includes gear description, effort by date, number of hooks, and location, numbers by sex for target species. Summaries are available.

Observer data

Observer data are available from the drift gill net fisheries (for thresher, shortfin mako and blue) from 1980 to 1986. Mandatory and volunteer catch records include catch, time and area, effort (number of observed sets), gear, number and species of incidental catch. This program was designed to identify incidental catch of marine mammals and recreational species. A total of 355 observations on 79 vessels were recorded between 1980 and 1984. This does not represent a random sampling of vessels or fishing areas.

Observer data for the 1988 experimental longline fishery (shortfin mako and blue sharks) are similar to observer data from the DGN fishery but include mortality estimates for discarded blue sharks and covers approximately 20% of fishing activities.

Market Sampling

Market samplers have collected catch information for pelagic sharks since 1981 and for angel sharks since 1986. Catch in pounds and number for each species is obtained and provides length-weight structure. Some sex ratio data became available in 1987 and is required in 1989.

Recreational sampling

Boat launching ramp samplers conduct interviews and log books from charter boat are available. These are not consistent and do not specifically include shark charters or derbies. The Marine Recreational Fishery Statistics Survey was initiated by NMFS in 1979 to collect recreational fishing effort along our west coast. It consists of two independent surveys and has employed CDFG personnel. While published reports list all shark species under one heading ("shark") data by species can be retrieved.

Tag-recapture data

Approximately 2500 sharks (blue, mako, angel & thresher) have been tagged since 1984 with nearly 50 recaptures to date.

In Washington and Oregon there were no directed gill net or long line fisheries for sharks prior to 1983, although a small established fishery for soupfin sharks continues. A limited number of thresher sharks were landed during 1983 through 1985.

Market Receipts

Market receipts show total pounds by species and species group (shark) , time and area. DGN Permit system for threshers has been required since 1986 and was designed to capture catch effort and size of threshers.

Log Books

Log books have been required since 1986 and include catch by species, location and incidental take.

Fishery observers

Observers have been riding fishing vessels since 1986. Data collected include catch by species, location and incidental take.

Market sampling

Market sampling for the thresher shark fishery has been conducted since 1986. Samplers provide length/weight structure, catch, and sex ratio data. Some hard tissues for age determination are being collected.

Recreational sampling

In addition to the MRFSS both Washington and Oregon collect recreational catch information. Although most of the information concerning sharks is lumped into a general "shark" category, some species specific data are available.

STATUS OF AVAILABLE BIOLOGICAL DATA FOR SHARKS

Since the commercial catch is usually limited by economic conditions or management regulations to only a portion of any specific stock, fishery dependent catch data may not accurately reflect population characteristics. Population data must often be acquired through fishery independent methods such as sampling surveys and mark-recapture studies. Much of the information necessary to develop reliable abundance indices is lacking for west coast sharks. Life history data is also lacking or only known for closely related species.

Distribution

The distribution of the commercially important species of west coast sharks are primarily known from domestic and international fisheries catch data. Fishery stocks for some species are well established, although there have been no fishery independent studies to determine boundaries for biological stocks. While the literature does contain much useful data on distribution there is little on abundance. Further, the fishery data that does exist is only for California, Oregon and Washington and does not include data from Mexico, Japan and other shark fishing countries.

Generally elasmobranchs exhibit sexual and adult-juvenile segregation at some time in their life. Seasonal changes also play an important roll in apparent abundance. Identifying the distribution of adult spawning stock, as well as non-spawning adults, puping grounds and nursery areas are all critical to developing a population structure and abundance indices.

Females may move into nursery areas to give birth and presumably depart to join the males and breed for next seasons brood. After birth, the pups are immediately on their own but may remain in nursery areas for a number of years before joining the adult population.

This is particularly evident for thresher sharks and is probably true for the shortfin mako and blue sharks as well. The southern California Bight appears to be a nursery area for an number of pelagic, migratory sharks. Catch data indicate thresher shark young migrate into relatively shallow water near shore. They remain in these nursery areas for two to four years and then apparently move off shore to become coastal pelagic adults. This adult population moves northward to at least the state of Washington during the summer. The southern limit of distribution extends south to at least mid-Baja California. Juveniles are taken in Santa Monica Bay by commercial and recreational fishermen. The boundaries of this nursery area are not clearly defined.

Less is known about the shortfin mako shark. The nursery area is apparently limited on the north to Point Conception, south to somewhere in Mexico. The distribution of the adult population is world wide and is known largely from commercial landings. West coast fisheries capture juveniles (1-2 year olds) close to shore with occasional sub-adult and adult fish being taken.

There are little data on the distribution or abundance of blue sharks in the Pacific, although it is known to occur over a broad range. Good catch data exists for an experimental fishery involving only one vessel (West Coast Fisheries Development Foundation 1981) along with some trial long line surveys targeting on swordfish. Geographically angel sharks are more isolated than their pelagic relatives. There is little information where the new borns and juveniles live or at what age they are recruited.

Age and Growth

Good progress has been made in determination of age and growth of many elasmobranch species. Cailliet (MS 1989) has reviewed recent studies of age determination of 46 species of elasmobranchs. Periodicity of translucent growth zones appearing in calcified tissues of six species of sharks have been age validated using multiple aging techniques. Thirty nine others were partially verified. These advances indicate continued success using multiple techniques to assist in determining proper age and growth in sharks.

Only one species, the angel shark, has not shown a predictable periodicity in band deposition. These attempts at aging angel sharks (Natanson 1986, Cailliet MS 1989) indicate growth is somatic and not annual.

One of the major problems for all species of sharks is to identify maximum age of spawning for adults. The technology and resources are available to analyze vertebrae from large specimens of a variety of species.

Reproduction

Reproductive habits vary widely between species of sharks. Age and size at maturity, number of developing embryos and pups born, length of gestation, etc., are described in the literature. Recent studies of elasmobranch reproduction have provided good estimates of fecundity for most of the shark species in west coast fisheries. Less known if some females rest between reproductive cycles (Springer 1960, Pratt 1989, others).

Natural Mortality

Natural mortality is poorly understood for most of these species although a range of estimates can be predicted from work completed on related species (Pauly 1980, Hoenig 1983, Hanan 1984). All have indicated a range for M of between 0.1 and 0.2.

Recruitment

Little is known about recruitment in these west coast shark populations. While fecundity estimates are available for most species, little is known about actual rates at which juveniles enter the fishable populations. Current tagging studies have not had enough effort to produce enough returns to provide for reliable estimates of recruits. Attempts to tag thresher sharks have been unsuccessful. Initial tag returns from California indicate an 8 percent return rate of shortfin mako sharks over a 250 tag effort. Returns from tagging blue sharks have been 1 percent for approximately 1500 sharks tagged. Tag and recapture studies can provide information to help resolve questions concerning recruitment of young and the adult migration (movement) patterns.

STATUS OF STOCK ASSESSMENT METHODOLOGY

No single model, procedure, or set of procedures has been developed which has demonstrated a universal applicability to the assessment of shark populations. This is due, at least in part, to the inconsistent or incomplete data available to the scientist. When data sets are complete it is usually too late to protect a species from overharvest. Fishing technology may also dictate circumstances which lead to one analytical procedure over another. Imposed regulations to protect a portion of a particular fishery or an endangered by-catch will influence the approach as well.

Off the west coast of the U.S. attempts at assessments of shark populations have led to as many methodologies as there are shark fisheries. These previous attempts at modeling and/or assessment of shark stocks have made use of length-frequency analysis, catch per unit of effort indices and life history tables. These are summarized for each of the major west coast species below.

Thresher shark

A series of length frequency histograms collected over a period of 8 years has been used to postulate a theoretical picture of a west coast thresher shark stock. It asserts that an entire size segment, representing the middle-aged portion of the stock, has been effectively removed by directed fishing pressure. By compiling landing receipts over the period scientists were able to reconstruct the structure of the unexplioted stock (Cailliet and Bedford 1983). Theoretically this information, together with valid parameters on growth and mortality, could allow a modeling reconstruction of the entire stock. The model has not yet been attempted, but an aggressive assertion of this theoretical stock age structure in concert with declining catches has led to an incremental cessation of all directed fishing off California.

Indices of catch per unit of effort have been used in both Delury and Leslie depletion models to estimate the Pre-exploitation biomass (Bedford, ref.?). An attempt was made to track individual cohorts over four years through an age specific CPUE index. Unfortunately the results displayed a lack of continuity between years, most likely due to incorrect age assignment and/or erroneous assumptions concerning the selected parameters.

Shortfin mako

A series of length-frequency histograms has been used to postulate that waters off southern California represent part of a nursery area containing predominately one and two year old fish (Cailliet and Bedford 1983). No other models or assessments have been attempted.

Blue shark

No assessment has been attempted for this species.

Pacific Angel Shark

Utilizing available literature and tag-recapture data, estimates of age, natural mortality and fecundity were incorporated into a life history table (Bedford 1987). From this table a minimum capture size was selected that would allow for replacement. There have been no other assessments.

Soupfin Shark

No assessments have been attempted.

RECOMMENDATIONS

General

With the present knowledge of elasmobranch biology and vulnerability to fishing pressure it is clear that these populations must be protected from over harvesting. Historical patterns of shark fishing confirm this in all cases. All evidence indicate careful monitoring is necessary to protect these species. There is, however limited information available for determining the status of these delicate stocks of fish. It was the conclusion of this group that a tremendous amount of data is necessary to accomplish reliable stock assessments of the shark species addressed at this workshop. Their recommendation is to encourage and support the expedient acquisition of needed data outlined below and that fishery managers should proceed at a most conservative level when dealing with all shark populations.

To resolve many of the questions concerning critical life history parameters the existing tagging program should be expanded to provide adequate tag-recapture data. There should be an effort to obtain complete vertebrae collections for aging work, spanning all size classes within any given population.

Independent reproductive studies should be conducted on the west coast, even for species which have been well studied in other parts of the world. Studies on genetic variables, such as mtDNA, should be encouraged as an aid to stock identification.

A model should be developed for broad application to west coast shark stocks. It should assume that total biomass estimates are impractical due to the paucity of data, but that certain life history parameters can be reasonably estimated. The model would be derived from a yield per recruit model, but would solve instead for an optimum spawning potential, e.g. spawnings per recruit. The model would allow the manager to adjust fishing pressure to achieve some optimum value of fishing mortality (F), such that the shark population might be allowed to realize some acceptable percentage of its pre-fishing spawning potential.

Specific Recommendations

A. Thresher Shark Fishery

1. Data requirements

There is good length-frequency data over the period of the fishery. Major shifting of the size structure as a result of fishing pressure provides for a fairly accurate estimate of the original stock size. Distribution of both the juvenile and spawning adult stock outside the fishing grounds poorly known.

Catch and length-frequency data from Mexico's Pacific fisheries is critical to assessment needs and efforts to obtain the information should begin as soon as possible.

Continue market sampling for length-frequencies from the incidental catches in the swordfish and halibut fisheries to identify if and when, the age structure begins to return to pre-fishery proportions.

2. Biological Parameters

The reproductive life span of spawning females is not established. Vertebrae samples from very large individuals, along with evidence of reproductive variability are needed for age analysis to complete the growth curve and determine length of reproductive senescence.

Length-frequency data from both the directed and incidental fisheries is necessary to provide adequate age structure information. Continue monitoring length-frequency data from the fishing areas off Washington and Oregon to determine when the missing age class from California's fishery moves into that area. Failing this, a fishing vessel should be chartered to sample the size distribution in the fringe areas of the known fishing grounds.

Electrophoretic and DNA analysis of thresher stocks should be supported and continued to determine genetic relationships world wide.

3. Analytic Approach

Test the validity of the "theoretical population" by setting up a simulation model to test for signs that the model is accurately predicting observable outcomes.

Recruitment changes might be monitored as an index of CPUE established from the by-catch of the near shore halibut gill net fishery. Fishery data and biological parameters are sufficient to begin this work.

B. Shortfin Mako Shark Fishery

1. Data Requirements

The distribution of the adult spawning stock is virtually unknown. The extent of the shortfin mako sharks nursery area into Mexican waters must be determined before an assessment can proceed. It is critical for the assessment of this stock to identify the distribution of juveniles and adults from the Mexico shark and tuna longline fisheries.

There is a high priority to monitor the length-frequencies from the DGN and experimental longline fisheries.

Increased effort to monitor recreational catch of shortfin mako sharks is necessary. The Marine Recreational Fishing Survey should be encouraged to increase regional coverage

of this important stock. Random telephone surveys and dock-side fisherman interviews should be expanded.

2. Biological Parameters

Length frequency data from domestic and the Mexican fisheries can provide additional age structure and mortality information.

There is a serious lack of consistent effort data in the drift gill net fisheries. California's present experimental longline fishery should be continued at its current fixed quota to provide standardized effort data over an extended period. Future expansion expansion would depend on analysis of assessment models as results became available.

An expanded tagging program should be conducted to determine movement patterns in the juveniles, to support age and growth studies, and to provide for an eventual estimate of recruitment. This tagging effort should include a dedicated survey vessel and personnel. The growing recreational fishery for short fin mako sharks should also be included in the program.

Vertebrae samples from large fish are needed to improve age and growth estimates in the oldest adults. Genetic stock differences need to be clarified through mtDNA and electrophoretic studies.

3. Analytic Approach

Definition of a west coast nursery area could lead to an "order of magnitude" assessment of population biomass. One and two year old cohort strengths could be estimated from tag and recapture data and with estimated mortality, produce estimates of total population biomass. If a commercial fishery for the shortfin mako is going to be developed, then a conservative quota should be established for a number of years while data is gathered for assessment.

C. Blue Shark Fishery

Although there has not been a directed fishery for blue sharks since 1980, new markets for blue shark fins have opened along the Atlantic coast and it may only be a matter of time before similar markets are created of the west coast. All aspects of California's experimental longline fishery should be monitored to ensure a good baseline length-frequency data set is collected now so that changes latter in the fishery will be comparable. Recreational interest in the blue shark is also increasing and should be monitored through the Marine Recreational Fishery Survey.

D. Angel Shark Fishery

Angel sharks remain alive in the commercial set nets and under sized fish (less than 42 in) are returned to the sea, usually in healthy condition. This provides a unique opportunity to collect much needed assessment information.

1. Data Requirements

Age and growth studies have not been validated. Length frequency data is needed from all size classes of angel sharks in order to establish a reliable population size structure.

2. Biological Parameters

Aging and growth studies are under way, but this particular species poses unresolved problems. This information is critical to assessing the angel shark stock. Some recent advances are occurring and research in this area should be supported and encouraged.

A large scale tag and recapture effort should be undertaken. This information is necessary to prepare population size estimates, migration patterns and to help improve the growth curve.

There may be isolated stocks of angel sharks located at several of the southern California Channel Islands. If this is true, then this presents an opportunity for experimentation with such concepts as fishery dependent compensation, and might allow for distinction to be made between natural and fishing mortality as a measurement between the length composition of fish from exploited and unexploited islands.

Federal marine life observers aboard fishing vessels (category 1 & 2 vessels) should measure, sex and tag as many under sized angel sharks as practical within the scope of their other duties.

The location and distribution of new born pups is poorly known. A research survey is needed to identify the distribution of the nursery area.

3. Analytic Approach

A paucity of data prevents any meaningful assessment at this time. However, continuing to refine and improve data for the life history table will help in estimating recruitment. An attempt to develop CPUE indices from the fishery log books should also be undertaken as soon as those log books become available.

E. Soupfin Shark

1. Data Requirements

Length-frequency data is needed from both the directed fishery and from the incidental catch to compare with historical data.

2. Biological Parameters

Most biological parameters were worked out in the 1940's although there has been no recent age determination analysis using modern techniques. These studies are encouraged to verify previous works.

3. Analytic Approach

Since the pre-war fishery resulted in the collapse of the soupfin stock, historical data can be used to estimate total, pre-exploitation biomass. Length composition from current fisheries should be compared to these historical records to determine any similarity in stock structure. Since nearly 50 years have passed, current stocks could be assumed to have returned to approximately these levels.

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Table 1. West Coast Commercial Shark Landings - pounds

NAME	1988*	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976
PACIFIC ANGEL	473,158	940,136	1,241,130	1,237,810	633,250	351,344	317,953	260,031	110,022	123,652	82,383	366	690
THRESHER, BIGEYE	4,270	25,303	46,184	119,632	74,769	106,507	36,269	10,542	10,842				
BLUE	493	3,907	2,850	2,356	3,940	13,983	57,838	202,898	192,130	83,966	35,904	98,365	9,928
MAKO, SHORTFIN	475,337	611,980	456,063	215,126	244,021	322,953	527,677	275,830	155,336	35,334	27,436	19,911	2,293
SMOOTHOUND, BROWN		12,905	13,506	33,312	8,091	14,101	5,263	23,641	5,783	2,440	7,365	264	20
THRESHER, COMMON	605,312	769,913	1,215,165	1,528,766	1,662,587	1,757,353	2,386,585	1,937,618	1,806,002	735,602	302,073	129,522	46,887
COW		358	439	427	1,333	1,258	1,328	771	438	290	249		35
DUSKY						120		196			103	202	50
SMOOTHOUND, GREY			506	1,874	6,846	1,055	2,520		761	12,046	33,745		
HORN		53	197	363	613	485	7,541	2,286	8,465	21,055	273	1,156	60
LEOPARD	4,333	55,343	65,826	75,695	69,187	101,309	70,666	49,380	40,085	26,966	34,956	22,267	14,590
THRESHER, PELAGIC		2,294	237	640		10,923						77	
SALMON		255	2,252	2,016		230	996						
SEVENGILL		170	55	893	282	1,735	2,041	3,415	545		84		
SIXGILL		55		4	96	128		317	12	20			
HAMMERHEAD, SMOOTH		1,807	3,628	3,920	6,831	44,481	1,866	2,259		304	1,025	1,860	
SOUPFIN	129,504	227,737	197,164	243,661	558,280	176,155	249,070	257,348	192,119	221,840	176,070	162,166	182,390
SPINY DOGFISH		8,071,022	5,009,433	2,837,927	7,649,393	5,398,532	4,591,551	4,831,846	7,141,280	9,445,000	6,522,003	5,813,147	22,697
SWELL				20	222				163		2,795		
UNSPECIFIED, SHARK	546,939	178,098	135,146	193,317	181,373	181,373	273,721	580,932	1,158,219	840,956	600,473	563,382	582,450
GREAT WHITE		1,343	923	2,861	6,102	634	8,052	42	1,660	2,269			
TOTAL U.S. SHARKS		10,902,679	8,288,824	6,500,620	11,107,244	8,481,489	8,541,837	8,439,352	10,823,862	11,551,740	7,826,837	6,812,685	862,090

* Incomplete data

Appendix A. Workshop Objectives, Venue and Agenda

TITLE: Assessment methods workshop for sharks.

OBJECTIVES: Review information on population biology and methods for stock assessment of shark stocks in California. Five specific questions will be addressed:

1. Which shark stocks are in need of assessment studies and in what order should they be studied?

2. What techniques are best used for assessing shark populations?

3. What data and information are required for applying these techniques and for estimating population parameters?

4. What new studies need to be initiated for completing assessments?

5. Considering available research resources, who can best accomplish the task of conducting the stock assessments and undertaking required research studies?

SPONSOR: National Marine Fisheries Service, Southwest Fisheries Center (SWFC), and the California Department of Fish and Game, Long Beach.

ORGANIZERS: David Holts, Southwest Fisheries Center, La Jolla and Dennis Bedford, California Department of Fish and Game, Long Beach.

VENUE: Southwest Fisheries Center
8604 La Jolla Shores Drive
P. O. Box 271
La Jolla, CA. 92038
619-546-7000

DATE: February 15 & 16, 1989.

REPORT: A report of the workshop will be prepared by the organizers and printed for distribution in the SWFC Administrative Report series.

WORKING AGENDA

Wednesday February 15, 1989

0800 Coffee

0830 Welcome

Introduction

- House keeping
- Workshop objectives - review of fisheries management
- Overview of specific fisheries and existing data sets

0900 Review of assessment procedures relative to elasmobranchs

- Modeling techniques
- Statistical methods

1200 Lunch

1300 Review of available fishery data sets

- Data set parameters
- Time series
- Quality

Review of existing biological parameters by species

1700 Adjourn

Thursday February 16, 1989

0800 Discussion of new research needs, by species and how those needs will be met.

- Thresher shark
- Bonito shark (Shortfin Mako)
- Angel shark
- Blue shark
- others

1200 Lunch

1300 Continue discussions

Recommendations and closing remarks

Adjourn

Appendix B. Participants

Dave Au	NMFS, Southwest Fishery Center, La Jolla, CA
Norm Bartoo	NMFS, Southwest Fishery Center, La Jolla, CA
Dennis Bedford	Cal. Dept. Fish and Game, Long Beach, CA
Gregor Cailliet	Moss Landing Marine Lab., Moss Landing, CA
John Casey	Northeast Fishery Center, Narragansett, RI
Doug Chapman	University of Washington, Seattle, WA
Al Coan	NMFS, Southwest Fishery Center, La Jolla, CA
Doyle Hanan	Cal. Dept. Fish and Game, La Jolla, CA
Dave Hansen	Pac. Mar. Fish. Comm., Portland, OR
Tom Hoff	Mid-Atlantic Fishery Management Council, Dover, DE
Dave Holts	NMFS, Southwest Fishery Center, La Jolla, CA
Larry Hreha	Ore. Dept. Fish and Wildlife, Portland, OR
Rick Klingbeil	Cal. Dept. Fish and Game, Long Beach, CA
Alec MacCall	NMFS, Southwest Fishery Center, Tiburon, CA
Larry Massey	NMFS, Southeast Fishery Center, Miami, FL
Jack Musick	Virginia Institute of Marine Science, Gloucester Point, VA
Gary Sakagawa	NMFS, Southwest Fishery Center, La Jolla, CA
Bob Skillman	NMFS, Southwest Fishery Center, Honolulu, HI
Kurt Stick	Washington Department of Fish, Seattle, WA
John Sunada	Cal. Dept. Fish and Game, Long Beach, CA